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Facultative xenogamy and melittophily in Tiger's Claw, *Martynia annua* L. (Martyniaceae)

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ABSTRACT

Martynia annua is a seasonal shrubby herb. It shows its vegetative growth, flowering and fruting during wet season. The floral traits characterize the melittophilous pollination syndrome and accordingly pollinated exclusively by carpenter bees. The flowers present protandry and lack herkogamy, the combination of which enables the plant to display facultative xenogamy. Spontaneous autogamy occurs at any time after the commencement of stigma receptivity depending on the level of proximity of the stamens and stigmatic lobes to each other. Fruits are dehiscent and dispersed by animals/humans. The study indicates that the plant species with facultativey xenogamy and melittophily is able to grow and expand its distribution in tropical regions as a seasonal invasive weed.

Key words: *Martynia annua*, facultative xenogamy, melittophily, zoochory.

1. INTRODUCTION

The genus *Martynia* is a monotypic genus and represented by a single species, *M. annua* in Martyniaceae family. It is native to Mexico, Central America and the Caribbean (Gutierrez 2009; USDA-ARS 2016). It is widely cultivated as a medicinal and ornamental herb due to which it has become naturalized in Australia, New Caledonia, South-eastern Asia, India and tropical Africa (MacKee 1994; Smith 2002; Flora of China Editorial Committee 2016; PROTA 2016; Weeds of Australia 2016). This herb grows as a seasonal weed along roadsides and riverbanks, moist thickets, disturbed sites, waste lands and pasture lands (Taylor 1983; Gutierrez 2009; Weeds of Australia 2016). In India, it is a common constituent of wastelands, pastures and disturbed lands (Kenwat et al. 2013). Kadereit (2012) reviewed pollination syndromes in Martyniaceae family. He described the function of melittophilous and sphingophilous syndromes in this family; the former is functional in *Proboscidea, Ibicella* and *Holoregina* while the latter is functional in *Craniolaria.* Philippi and Tyrl (1979) mentioned that Proboscidea louisianica is facultative xenogamous which is functional through protandry and the absence of

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herkogamy. Cardenas-Ramos et al. (2018) reported that *M. annua* is protandrous and lacks herkogamy. These authors based on out-crossing index stated that this plant is xenogamous. It is visited by bees such as *Centris agilis*, *Caenaugochlora* sp., *Euglossa viridissima, Friesemelitta nigra, Trigona fulviventris* and one noctuid moth. Philippi and Tyrl (1979) stated that the morphological features of *M. annua* flowers are also present in *Ibicella* and *Proboscidea* genera of Martyniaceae family. *M. annua* is visited only a single bee species, *Trigona fulviventris* in Mexico (Ayala 2004) and by carpenter bees, digger bees and hawkmoths in India (Rao and Reddi 1994). But, the information available on reproductive aspects of *M. annua* in public domain is insufficient to understand the pollination syndrome and mating system. It is in this context, the present study is attempted to provide certain details of pollination syndrome and mating system.

2. MATERIALS AND METHODS

Wild patches of *Martynia annua* growing on the Andhra University campus, Visakhapatnam, India, were used for conducting the present study during June 2021 to November 2021. It is a herbaceous weed which produces blankets of populations in open areas which receive sunlight directly. Ten inflorescences were tagged and followed to record the flower-opening schedule. The flowers opened on the same inflorescences were used to record the timing of anther dehiscence and stigma receptivity period. The floral features were recorded in detail to evaluate the pollination syndrome. Nectar volume and sugar concentration aspects were recorded. The daily schedule of flower visitors to the flowers was noted. Their flower approach, probing manner and their contact with floral sex organs was carefully observed in the field to evaluate their role in pollination. Fruit characters are briefly noted to record fruit dispersal and mode of seed dispersal.

3. RESULTS AND DISCUSSION

It is a seasonal erect shrubby herbaceous weed covered with glandular hairs. The leaves are petiolate with broadly cordate mucilaginous lamina with dentate margins and acute apex. The plants appear and complete sexual reproduction within the wet season from July to October in the study area. But, it displays flowering year-long in China (Flora of China Editorial Committee 2016) and from July to October in Central America (Gutierrez 2009). In this study the floral aspects are carefully observed to identify the functional pollination syndrome. The flowers are pedicellate, pale-pink to reddish purple, bisexual and zygomorphic. The are borne in a few-flowered peducunlate racemes which are borne at the bifurcation of the branches (Figure 1a). All parts of the inflorescence bears sticky glandular hairs. The calyx has five greenish-white ovate-0blong sepals which are laterally connate to half of their total length forming a tube with a ventral slit. The corolla is tubate, very long (15 cm), purplish-white and extended into 5 rounded spreading lobes of which only the basal one is widened. All 5 lobes have dark purple spots on their innerside but the widened lobe has an additional yellow colored nectar guide below the purple spot which runds down into the corolla tube. The stamens are 5 of which 2 are fertile with white pollen, 2 others large staminodes and 1 small (rudimentary) staminode. The fertilie stamens and staminodes are inserted near the base tube of the corolla. The ovary is bicarpellate, paracarpous with two T-shaped massive parietal placentae dividing into 4 peripheral 1-ovuled compartments with a central lacuna. The style is slender and tipped with a curved bilobed stigma. At the base of the ovary, an annular hypogynous disk is present. Fruit is a bi-valved, ovoid dorso-ventrally flattened, ribbed and pubescent drupe with 2 sharp recurved hooks at the tip. It is loculicidally dehiscent at maturity and splits into two portions. Seed number varies from 1 to 4; they are laterally compressed with winged ends and the recurved hooks facilitate seed dispersal by sticking to animal fur or clothes and the seeds in the drupe fall out eventually as the drupes get crushed by the feet of animals or humans.

Mature buds begin to open from 0400 h and become fully open by 0700-0800 h. Flower-opening means the unfolding and widening of petal lobes exposing the sex organs but the latter remain inside the corolla tube only. The flowers are nectariferous and produce 10 µl of nectar with 27 to 38% sugar concentration. The anthers dehisce by longitudinal slits while in mature bud stage itself while the stigma becomes receptive 3 hours after flower-opening. The stamens and stigma are not spatially separated during the entire duration of flower-life. The close proximity of these sex organs and the curved state of the bilobed stigma appear to be facilitating the occurrence of spontaneous autogamy but its occurrence to 100% is doubtful and hence, warrants for pollination to be effected by pollen vectors. The weak protandry, production of nectar and the presence of nectar guide on the widened petal lobe indicate that the flowers are principally evolved for pollination by pollinating vectors and the scope for spontaneous autogamy is only after the attainment of stigma receptivity. It is appropriate to state that protandry is a method to avoid selfing (Richards 1986) and the absence of herkogamy facilitates the occurrence of autogamy eventually. This fail-safe mating system is a requirement for *M. annua* in order to flourish as an invasive weed in different habitats. This mating system is reported in the facultative xenogamous species, *Proboscidea louisianica* which belongs to Martyniaceae (Phillippi and Tyrl 1979).

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Kadereit (2012) made a review of flower syndromes in Martyniaceae family. In this family, the genera *Proboscidea, Ibicella* and *Holoregina* exhibit a melittophilous syndrome while the genus *Craniolaria* exhibits a sphingophilous syndrome. In melittophilous genera, the bilobed stigma is appressed to the upper portion of the corolla tube and positioned near the throat of the corolla tube. The anthers are situated just below the stigma and in the latter, the lower lobe is sensitive to pollen and its sensitivity ceases as soon as it receives compatible pollen. In *M. annua*, the floral traits such as bilateral symmetry, fragrance, corolla color and rewards offered appear to have evolved by converged enforced by specialist flower visitors. The bilateral symmetry regulates or limits the approaching direction of the appropriate pollinators and the function of this symmetry is an indication of the presence of ecological coherence between the flower and the suitable flower visitors (Fenster et al. 2004; Sargent 2004).

Figure 1. *Martynia annua:* a. Shrub in flowering phase, b. Flower in hanging orientation and *Xylocopa latipes* reached the corolla tube base to collect nectar, c. *Xylocopa latipes* collecting pollen, d-f. *Xylocopa pubescens* – probing and collecting pollen.

Cardenas-Ramos et al. (2018) reported that the morphological features of *M. annua* flowers are commonly associated with melittophily. Phillippi and Tyrl (1979) reported that these morphological features are found in the genera of Martyniaceae, *Ibicella, Martynia* and *Proboscidea*. Ayala (2004) reported that *Trigona fulviventris* is the only known bee species that visits *M. annua* in Mexico. Rao and Reddi (1994) reported that *M. annua* is a seasonal invasive species in India. In this country, carpenter bees *Xylocopa latipes, X. pubescens*, the digger bee *Amegilla* sp. and the hawkmoth *Macroglossum gyrans* visit and pollinate *M. annua* flowers. Rao and Reddi (1994) further stated that the carpenter bees and the digger bee effect nototribic pollination and this mode of pollination is most economical because of deposition of pollen with great precision on the notum part which is not accessible for pollen grooming or gleaning by the bee. These authors also stated that the occurrence of pollination by hawkmoth is very remote because of no contact between the floral sex organs and the proboscis. In this study, *M. annua* is pollinated exclusively and consistently by carpenter bees, *Xylocopa latipes* (Figure 1b,c) and *X. pubescens* (Figure 1d-f) indicating that the floral architecture and floral traits of this species are well tailored for pollination by these bees only. These bees visited the flowers from 0800 h to 1600 h daily at the study site. Other bees reported by other workers appear to be opportunistic pollinators only. Therefore, *M. annua* with facultative xenogamous mating system is adapted for pollination by larged-bodied carpenter bees and hence this plant species is melittophilous.

4. CONCLUSIONS

Martynia annua is a seasonal shrubby herb. It begins and completes its life cycle within the rainy season. The flowers are positioned under the foliage and oriented horizontally. The floral traits indicate that this plant is evolved for melittophily. Accordingly, it is visited and pollinated exclusively by bees, in this study, only by carpenter bees. The function of protandry and the absence of

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herkogamy indicate that the plant is facultative xenogamous and the spontaneous autogamy occurs any time after the stigma is receptive depending on the proximity of the floral sex organs with each other. The fruits are dehiscent and dispersed by animals and humans. Therefore, the plant species with facultative xenogamy and melittophily is able to reproduce even without vector-mediated pollination enable it to invade different ecological niches and become an invasive weed in tropical regions.

Ethical approval

Martynia annua from Visakhapatnam, India, were used for conducting the present study. The ethical guidelines for plants & plant materials are followed in the study for sample collection & identification.

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Authors contributions:

Both authors contributed equally.

Conflicts of interests

The authors declare that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

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